RAW MATERIALS

UDC 553.61:549.08:622.7+666.715(470)

MINERALOGICAL AND TECHNOLOGICAL VARIETIES OF ARGILLACEOUS MATERIALS FOR CERAMIC BRICK AND CLAYDITE GRAVEL

A. V. Kornilov,[1] E. N. Permyakov,[1] and T. Z. Lygina[1]

Translated from Steklo i Keramika, No. 8, pp. 29 – 31, August, 2005.

The classification of clay materials into mineralogical and technological varieties is developed to asses their suitability for the production of ceramic brick and claydite gravel. Materials are divided into seven varieties based on their quality. The identification of the mineralogical-technological variety of a clay material allows for a reliable prediction of the finished product quality without carrying out a large number of labor-consuming tests.

A classification of argillaceous materials based on mineralogical-technological varieties has been developed based on parameters determined by adsorption luminescence analysis ALA (exchange capacity EC, clayiness number N_{cl}), static moisture capacity SM (weigh parts of adsorbed water H_2O_{ads} and absorbed water H_2O_{abs}, coefficient K, content of montmorrillonite component MC), and volumetric analysis VA (content of carbonates). The parameter H_2O_{abs} was determined for $P/P_{K_2CO_3} = 0.43$ and the parameter H_2O_{ads} for $P/P_{BaCl_2} = 0.92$ (P is the atmospheric pressure of water vapor; $P_{K_2CO_3}$ and P_{BaCl_2} is the water vapor pressure above the saturated solution of K_2CO_3 and $BaCl_2$). These methods are rather fast and simple (USSR Inventor's Certif. No. 1349497, USSR patent No. 1810009). They are used in geological survey of argillaceous materials for the production of ceramic bricks and claydite gravel.

Materials used for brick production are classified into 7 varieties depending on their quality: montmorillonite-hydromica clay are subdivided into varieties 3a, 3b, 4a, 4b, and 5a, hydromica clay is subdivided into varieties 5b and 6a (Table 1). The attribution of the clay variety makes it possible to predict the quality of material and of plastically molded brick (stone). The conclusions on the technological properties of argillaceous materials and the parameters of finished products depending on their mineralogical-technological varieties are based on a database of semiindustrial samples from over 100 clay deposits.

If more that 40% grog additive has to be introduced into a mixture to improve its drying properties, such material is regarded as substandard. For standard material the type of required additive (grog, plasticizing) and its approximate quantity (5 – 40%; here and elsewhere weight content) is indicated depending on exchange capacity and the content of montmorillonite, as well as the coefficient K reflecting the presence of kaolinite or calcite minerals.

Materials with an increased content of the montmorillonite component (19% and more) mainly require a grog additive. This should be a granular material, usually an inert one, with particle sizes in the range of 0.5 – 2.0 mm, which is prepared by milling and screening. When the content of the grog additive is above 30%, the material is regarded as substandard, since transportation of additives in such quantities is economically ineffective. A high content of inert filler also impairs the quality of brick. It is advisable to search for solutions based on the following variants of batch preparation:

– mixing clay materials of different quality;

– improving the quality of materials by special slip treatment with subsequent dehydration of the resulting mixture, fine milling of initial material, thermal treatment of a part of material (producing dehydrated clay), etc.

Material 4b potentially has better quality. It can be mixed with various additives (grog, burning-out, heat-generating), which makes it possible to produce bricks of different degree of hollowness of high-quality grades, including facing brick.

[1] Central Scientific Research Institute of Geology of Nonmetallic Mineral Materials, Kazan, Russia.

0361-7610/05/0708-0258

TABLE 1

Variety	Parameters	Predicted estimate of quality of material and product
3a	EC = 37 mg · equ, N_{cl} = 70 – 90 conv. units, H_2O_{abs} = 6.4 – 7.9%, H_2O_{ads} = 10.5 – 13.0%, K = 1.45 – 2.00, MC = 34.5 – 40.0%	Substandard
3b	EC = 32 mg · equ, N_{cl} = 45 – 70 conv. units, H_2O_{abs} = 5.4 – 6.7%, H_2O_{ads} = 9.0 – 12.0%, K = 1.45 – 2.20, MC = 30.0 – 34.0%	Substandard, unless lean or high-melting clay (30 – 40%) and granular grog component are added. Brick and stone with hollowness 27% and more. Drying duration 77 h. Product strength grade — 100 or more
4a	EC = 27 mg · equ, N_{cl} = 24 – 45 conv. units, H_2O_{abs} = 4.5 – 5.7%, H_2O_{ads} = 7.5 – 10.5%, K = 1.45 – 2.20, MC = 24.0 – 29.0%	Substandard, unless lean or high-melting clay (20 – 40%) and granular grog component are added. Brick and stone with hollowness 27% and more. Drying duration 77 h. Product strength grade — 100 or more
4b	EC = 23 mg · equ, N_{cl} = 14 – 24 conv. units, H_2O_{abs} = 3.5 – 4.9%, H_2O_{ads} = 6.0 – 8.5%, K = 1.45 – 2.20, MC = 19.0 – 25.0%	Standard (10 – 30% grog additive). Brick with hollowness 13% and more, stone with hollowness 25% and more. Drying duration 42 – 77 h. Product strength grade — 125 and more. Upon introducing 20 – 30% grog additive the brick is solid or with hollowness up to 13%. Drying duration 77 h. Product strength grade — 125 or more
5a	EC = 19 mg · equ, N_{cl} = 9 – 13 conv. units, H_2O_{abs} = 2.9 – 3.9%, H_2O_{ads} = 4.5 – 7.5%, K = 1.45 – 2.20, MC = 15.0 – 20.0%	Standard (10 – 20% grog additive). Brick with hollowness 13% and more, stone with hollowness 25% and more. Drying duration 42 – 72 h. Product strength grade — 125 and more. Upon introducing 20 – 30% grog additive the brick is solid or with hollowness up to 13%. Drying duration 77 h. Product strength grade — 125 or more
5b	EC = 13 mg · equ, N_{cl} = 4 – 9 conv. units, H_2O_{abs} = 2.1 – 2.9%, H_2O_{ads} = 3.7 – 6.0%, K = 1.45 – 2.00, MC = 10.0 – 15.0%	Standard (5 – 15% grog additive). Brick with hollowness 13% and more, stone with hollowness 25% and more. Drying duration 33 – 72 h. Product strength grade — 100 or more
6a	EC = 9 mg · equ, N_{cl} = 2.0 – 3.9 conv. units, H_2O_{abs} = 0.8 – 2.0%, H_2O_{ads} = 1.5 – 4.0%, K = 1.45 – 2.20, MC = 5.0 – 9.0%	Substandard unless plasticizing agent is added. Can be used as grog additive to plastic clays

The content of additives can be decreased and in some case it is admissible to shorten the drying duration of molded preforms.

Variety 5a is close to material 4b in its properties. Due to the lower content of the montmorillonite component, it is possible to lower the share of the grog additive in the batch for producing hollow brick and to produce solid brick as well.

As for material 5b, it is recommended to introduce a combination of additives, including a minimal quantity (5%) of granular (grog) material, a plasticizing additive to improve molding properties, as well as a flux to facilitate sintering. Such mixture of materials can be used to produce bricks of different degrees of hollowness but of lower grades than bricks made from materials 4b and 5a.

Material variety 6a is potentially substandard due to its poor molding properties and decreased sinterability. Only the introduction of large quantities of plasticizer and flux can make this mixture suitable for making bricks of rather high grades. This material can be effectively used as a grog additive to plastic clays.

Based on data obtained, it is possible to predict the type of the product (brick or stone with certain hollowness) that would have a minimum of defects in drying and the probable grade of this brick is specified.

The use of nontraditional investigation methods (ALA, SM, and VA) contributes to getting deeper and more reliable information on the quality of clay materials. Therefore, the semi-industrial testing of argillaceous materials can be replaced by generalized (experimental-industrial) testing provided the materials are preliminarily estimated using the proposed methods. These tests can be performed on low-volume samples on a specially designed technological line equipped with a set of necessary equipment.

The industrial standard specifies that testing in industrial conditions requires a sufficiently large batch of argillaceous material (60 tons). The extraction, transportation, and testing of such quantity of material involve substantial expenses.

Together with researchers from P. P. Budnikov VNIIstrom Institute we have developed and produced original equipment and the technological line for generalized (experimental-industrial) testing of argillaceous materials for the purpose of producing wall ceramics by plastic molding and semidry molding. This technological line has been put into service and certified at the analytical-technological testing center of the Central Research Institute of Geology of Nonmetallic Mineral Materials (TsNIIgeonerud) [1]. The equipment of this line meets the contemporary requirements of brick production technology and makes it possible to carry out generalized testing on small-scale samples weighing 0.5 – 1.0 tons.

During the operation of this line we have investigated argillaceous materials from over 20 deposits from different regions of the Russian Federation. The quality of serial product produced according to the recommended technological schedules is equivalent to the quality of experimental samples obtained on the technological line.

TABLE 2

Mineral composition group	Exchange capacity, mg · equ	Clayiness number, conv. units	Color of suspension with methylene blue colorant (grade)	K^{*} (grade)	Weight content, %			MC, %	Variety (grade)	Maximum total grade	Density,*** g/cm^3	Swelling coefficient***
					H_2O_{ads}	H_2O_{abs}	$CaCO_3^{**}$					
Montmorillonite	≥ 52	> 135	Blue**** (0.5)	≥ 1.66 (0.5)	> 15	> 15	< 0.5	> 50	1a (3)	4	< 0.20	> 4 – 5
	47	115 – 135	The same	The same	13 – 16	13.5 – 15.0	< 0.5	45 – 50	2a (2.5)	3.5	< 0.25	> 4
	42	90 – 115	″	″	12 – 15	12.0 – 13.4	< 0.5	40 – 44	2b (2)	3	< 0.30	> 3 – 4
Montmorillonite-hydromica	37	70 – 90	″	″	10 – 14	11.0 – 11.9	< 1.0	36 – 39	3a (1.5)	2.5	< 0.35	> 3
	32	45 – 70	″	″	9 – 12	9.3 – 10.9	< 1.0	31 – 35	3b (1)	2	< 0.40	> 2.5
	27	24 – 25	″	″	8 – 11	7.8 – 9.2	< 2.0	26 – 30	4a (0.5)	1.5	< 0.50 – 0.60	~ 2.5
	23	14 – 24	″	″	7 – 9	6.3 – 7.7	< 3.0	21 – 25	4b (0)	1	> 0.60	< 2.5

* At K less than 1.66 — grade 0.

** With organocalcite impurity (over 0.2% $CaCO_3$) — total grade is equal to 0; with 3 – 6% (free) $CaCO_3$ the total grade is lowered by 1; with more than 6% (free) $CaCO_3$ the total grade is equal to 0.

*** The quality prediction is given for material in the natural state fired at 1170 – 1200°C. On introducing 0.5% fuel oil, the parameters improve by 1 – 2 degrees (one or two lines higher in the last two columns).

**** In the case of purple-blue, blue-purple, or gray-brown color — grade 0.

The attribution of clay materials used for claydite gravel to a particular mineralogical and technological variety and prediction of claydite swelling is based on the exchange capacity value taking into account the content of the montmorillonite component. Both parameters have to be numerically close. Next the general grade is calculated as the sum of positive grades obtained by the ALA and SM methods and the negative grades depending on the content of calcite and the form of its incorporation (Table 2). Furthermore, in attributing clay materials it is recommended to additionally use Mossbauer (nuclear gamma-resonance) spectroscopy to identify the structural forms of iron ions. The parameters of quadruple splitting and isomeric shift characterizing the structural and valence state of iron ions and the degree of filling of a particular structural position [2] can be used as well to evaluate the propensity of clay materials to swelling.

The identification of the mineralogical-technological variety of argillaceous materials in estimating its applicability to producing ceramic brick (stone) and claydite gravel makes it possible to reliably predict the quality of finished product without carrying out a large number of labor-consuming tests.

REFERENCES

1. A. V. Kornilov and A. F. Shamseev, “Production of hollow porous ceramic brick from mineral materials of the Republic of Tatarstan,” *Stroit. Mater.*, No. 7, 2 – 4 (2003).
2. M. V. Éirish, Sh. Sh. Bashkirov, E. N. Permyakov, and A. B. Liberman, “The study of correlation between Mossbauer characteristics of isomorphic iron ions in montmorillonite and the crystal chemistry and genesis of material,” in: *Proc. IV All-Union Symposium on Isomorphism* [in Russian], Elista (1977), pp. 90 – 100.